ANSWERS: Precipitation

1)

1	Lead iodide	PbI_2	yellow
2	No precipitate		
3	Copper hydroxide	$Cu(OH)_2$	blue

In **Beaker 1**, there are Pb^{2+}, NO_3^-, K^+ and I^- ions present. When mixed, a yellow precipitate of PbI_2 will form because iodides of lead are insoluble. It will not be KNO_3 because all nitrate compounds are soluble. K^+ and NO_3^- ions are the spectator ions.

$Pb^{2+}(aq) + 2I^-(aq) \rightarrow PbI_2(s)$ OR

$2KI(aq) + Pb(NO_3)_2(aq) \rightarrow PbI_2(s) + 2KNO_3(aq)$

In **Beaker 2**, there are Na^+, Cl^-, NO_3^- and Fe^{3+} ions present. No combination of these produce an insoluble substance (precipitate) according to the solubility rules as sodium compounds are all soluble, as are nitrates. Chlorides are also soluble (except for silver and lead), so no chloride precipitate will form either.

In **Beaker 3**, there are Cu^{2+}, SO_4^{2-}, Na^+ and OH^- ions present. All sodium compounds are soluble, but a blue precipitate of copper hydroxide forms as this is insoluble. The Na^+ and SO_4^{2-} ions are spectator ions.

$Cu^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(s)$

OR

$CuSO_4(aq) + 2NaOH(aq) \rightarrow Cu(OH)_2(s) + Na_2SO_4(aq)$

2) In test tube A, a white precipitate / solid / deposit forms (or the solution turns cloudy white). The precipitate / solid / deposit is lead sulfate.

In test tube B, a yellow precipitate / solid / deposit forms (or the solution turns cloudy yellow). The precipitate / solid / deposit is lead iodide.

The type of reaction occurring in each test tube is a precipitation reaction (or exchange reaction) because when the two solutions are added together an insoluble substance called a precipitate forms. This settles at the bottom of the test tubes, so they are both precipitation reactions.

(OR ... because when the two solutions are added together ions from each substance are swapped or exchanged and an insoluble substance forms, so they are both exchange reactions.)

Candidate could provide an ionic or a molecular balanced symbol equation.

A: $Pb^{2+}(aq) + SO_4^{2-}(aq) \rightarrow PbSO_4(s)$

OR

$Pb(NO_3)_2(aq) + K_2SO_4(aq) \rightarrow PbSO_4(s) + 2KNO_3(aq)$

B: $Pb^{2+}(aq) + 2I^-(aq) \rightarrow PbI_2(s)$

OR

$Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow PbI_2(s) + 2KNO_3(aq)$

3) An aqueous solution of silver IONS can be used to test for chloride ions.

It is a precipitation reaction. Silver chloride would form a white precipitate if the pool water was mixed with the aqueous silver solution. The white precipitate forms because the Ag^+ ions are attracted (combine / join / bond) to the Cl^- ions in solution, forming insoluble AgCl / silver chloride.

The pool water is colourless and silver nitrate is colourless but when they are mixed, a white precipitate of silver chloride is formed showing presence of chloride ions in pool water.

$Ag^+ + Cl^- \rightarrow AgCl(s)$

(A white precipitate will also form with an aqueous lead solution, but it could be $PbCl_2$ or $PbSO_4$ if sulfate ions are present.

$Pb^{2+} + 2Cl^- \rightarrow PbCl_2$

Using an aqueous solution of lead ions may not confirm the presence of only chloride ions.)

4) A white precipitate forms in a colourless solution.

Calcium hydroxide $Ca(OH)_2$ precipitate would form.

The Ca^{2+} and OH^- ions would be attracted to each other to form the insoluble precipitate.

The Na+ and NO_3^- ions are soluble and would be found on their own in the solution as spectator ions.

$Ca^{2+}(aq) + 2OH^-(aq) \rightarrow Ca(OH)_2(s)$

OR

$Ca(NO_3)_2(aq) + 2NaOH(aq) \rightarrow Ca(OH)_2(s) + 2NaNO_3(aq)$

(Candidates are not required to write states in equations, but if molecular equation used, somewhere in answer calcium hydroxide must be correctly identified as the precipitate.)

5) Identification of beaker: Precipitate forms in Beaker A.

Ions formed: Pb^{2+}, NO_3^-, Na^+ and Cl^-.

Name of precipitate: Lead chloride, $PbCl_2$

Balanced symbol equation: $Pb(NO_3)_{2(aq)} + 2NaCl_{(aq)} \rightarrow PbCl_{2\,(aq)} + 2NaNO_{3\,(aq)}$

OR

$Pb^{2+}_{(aq)} + 2Cl^-_{(aq)} \rightarrow PbCl_{2(s)}$

No other precipitates:

The sodium and nitrate ions are spectator ions and do not react.

The other possible combinations of ions form aqueous solutions (lead nitrate and sodium chloride).

6) When a green solution of iron(II) sulfate is added to a colourless solution of potassium carbonate solution, a green precipitate forms. This precipitate is iron(II) carbonate.
Iron(II) carbonate is insoluble in water so forms a solid that will settle in the container. The potassium sulfate is soluble in water and since neither ion (K^+ and $SO_4^{\,2-}$) is coloured, the solution will be colourless.
$FeSO_4(aq) + K_2CO_3(aq) \rightarrow K_2SO_4(aq) + FeCO_3(s)$
$Fe^{2+}(aq) + CO_3^{2-}(aq) \rightarrow FeCO_3(s)$

7) This is a precipitation reaction. Calcium ions, Ca^{2+}, will react with hydroxide ions, OH^-, to form insoluble calcium hydroxide, $Ca(OH)_2$. The other ions in the reaction, potassium, K^+, and nitrate, NO_3^-, do not react with each other, so stay in solution. They are not written in the ionic equation; they are spectator ions.
$Ca^{2+}(aq) + 2OH^-(aq) \rightarrow Ca(OH)_2(s)$
$2KOH + Ca(NO_3)_2 \rightarrow 2KNO_3 + Ca(OH)_2$

8) Correctly identifies reaction 1. The ions in this mixture are $Pb^{2+,}$ NO^{3-}, Na^+ and Cl^-.
The sodium and nitrate ions are spectator ions and do not react. The lead ion and chloride ion do react to form the insoluble solid lead chloride. A (white) precipitate of lead chloride will form in the bottom of the beaker.
$Pb^{2+}(aq) + 2Cl^-(aq) \rightarrow PbCl_2(s)$

9) (i) silver chloride

(ii) no precipitate

(iii) calcium sulfate

$2AgNO_3(aq) + CaCl_2(aq) \rightarrow 2AgCl(s) + Ca(NO_3)_2(aq)$

OR

$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$

$Ca(NO_3)_2(aq) + Na_2SO_4(aq) \rightarrow CaSO_4(s) + 2NaNO_3(aq)$

OR

$Ca^{2+}(aq) + SO_4^{2-}(aq) \rightarrow CaSO_4(s)$

10) lead nitrate + potassium chloride → lead chloride + potassium nitrate

11) Precipitation. *(do not accept the abbreviation ppt)*

Each solution contains 2 aqueous ions. Barium nitrate contains Ba^{2+} and NO^{3-}, which are both colourless in solution. Iron(II) sulfate contains Fe^{2+}, which is green in solution and SO_4^{2-}, which is colourless in solution.

Ba^{2+} and SO_4^{2-} react to form an insoluble compound, barium sulfate, $BaSO_4$. This forms a white deposit (precipitate) at the bottom of the beaker.

$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

OR

$Ba(NO_3)_2\ (aq) + FeSO_4\ (aq) \rightarrow BaSO_4\ (s) + Fe(NO_3)_2\ (aq)$

Fe^{2+} and NO_3^- remain in solution. They do not react. The Fe^{2+} ions give the solution its pale green colour.

12) (i) no precipitate (ii) lead chloride (iii) magnesium hydroxide

$Pb(NO_3)_2(aq) + 2KCl(aq) \rightarrow 2KNO_3(aq) + PbCl_2(s)$

OR

$Pb^{2+}(aq) + 2Cl^-(aq) \rightarrow PbCl_2(s)$

OR

$2KOH(aq) + MgSO_4(aq) \rightarrow K_2SO_4(aq) + Mg(OH)_2(s)$

OR

$Mg^{2+}(aq) + 2OH^-(aq) \rightarrow Mg(OH)_2(s)$

13) (i) Calcium sulfate (ii) Copper hydroxide (iii) No precipitate

$Ca^{2+}(aq) + SO_4^{2-}(aq) \rightarrow CaSO_4(s)$

$Cu^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(s)$

OR

$Ca(NO_3)_2(aq) + Na_2SO_4\ (aq) \rightarrow CaSO_4(s) + 2NaNO_3(aq)$

$CuCl_2(aq) + 2KOH(aq) \rightarrow Cu(OH)_2(s) + 2KCl(aq)$

14) calcium sulfate, lead chloride, zinc carbonate

15) $CaCl_2\ (aq) + Na_2SO_4\ (aq) \rightarrow CaSO_4\ (s) + 2NaCl\ (aq)$

$Cu(NO_3)_2\ (aq) + 2NaOH\ (aq) \rightarrow Cu(OH)_2\ (s) + 2NaNO_3\ (aq)$

16) A red brown /orange precipitate would form.

The orange solution becomes colourless.

$Fe^{3+}\ (aq) + 3OH^-\ (aq) \rightarrow Fe(OH)_3(s)$

or

$FeCl_3(aq) + 3NaOH(aq) \rightarrow Fe(OH)_3(s) + 3NaCl(aq)$